degradation. In the degradation of such a plane the material is not taken up once for all and carried out to the sea (except of course that held in suspension), but is shifted little by little through cutting here and filling there, until, piece by piece and shift by shift through almost endless repetitions, the material is at length transferred to the sea. The newly formed portions of the equated plane would be liable to suffer this process over their whole surface during the stage of equilibrium and the early stages of degradation. It would be only when the degradation of the portions down stream had increased the gradient to such an extent as to lead to a contraction of the channel and the abandonment of a portion of the flood plane, that reworking of the surface parts would cease.

If, therefore, we assume the style of fluvio-glacial deposition postulated by Professor Wright, we find definite reasons for regarding the upper part of the Brilliant deposit as postglacial in origin, and find moreover special conditions that may have subjected it to reworking during the early stages of degradation that followed its construction. If, on the other hand, we assume that the glacio-fluvial deposits took the form of a common aggradation plane at the close of glacial action, the presumption is that the Brilliant terrace was carved out much later. It is just possible that the Brilliant deposits happened to be at the pivotal point between degradation and filling, and so were original — and the review admitted that they might be — but the more the case is studied the less probable this seems. T. C. C.

North American Fossil Crinoidea Camerata. By CHARLES WACHSMUTH and FRANK SPRINGER. (Memoirs Museum of Comparative Zoölogy.) Two parts, 800 pages, and atlas of 83 plates. Cambridge, 1895.

During the decade just passed our knowledge of ancient organisms has been enormously expanded, not so much through the old grooves of endless multiplication of species, as along lines in which the most recent conceptions of morphological inquiry are taken into consideration; or along lines having a direct bearing upon the interpretation of geological phenomena. Hence the differentiation of modern palæontology has been chiefly in two directions, and these departments are becoming so widely divergent that they will ere long, if some energetic steps are not taken to prevent it, cease to be of mutual aid. The

science as originally inaugurated was the foundation of modern stratigraphical geology; but of recent years the biological interest has developed so rapidly with the vast accumulations of remains of ancient organic life that this branch of the subject bids fair to soon cut loose entirely from the parent stem. No better illustration of this tendency has been shown than at a late gathering of the principal scientific societies of America. Of all the palæontological papers presented at the meetings not a single one was read before the Geological Society; the entire list was discussed at the biological associations.

The impetus given to palæontology in the direction of pure biology is timely, and the delay in entering that field may be ascribed chiefly to lack of sufficient and proper material for satisfactory study. The palæontologists of the new school have taken up the discussion of live organisms and their examination according to the latest and most approved methods in order that the long extinct forms of life might be interpreted more correctly. And the most advanced students of existing beings are beginning to look with less aversion than formerly to the fossils for the missing links for a complete phylogeny and ontogeny of living things. As the result of it all the value of organic remains for solving the intricate problems of the stratigraphic geology will be increased a hundredfold. The exhilarating effects have already begun to be felt in that branch of geological inquiry that was thought to be all but inert.

The life and racial histories of fossil vertebrates have for some time past yielded most beautiful and suggestive results. In the same direction the vastly more extensive groups of the invertebrate has in this country at least received scarcely a thought. Palæontologists therefore will hail with delight the appearance of Wachsmuth and Springer's masterly and exhaustive monograph on the North American camerata the most important branch of the crinoids. While it is first of all morphological from the foundation up, and the product of inquiries more thoroughly grounded in biological philosophy than any other work perhaps that has ever been issued on the fossil invertebrates in this country, it is also of such high utility in stratigraphy, especially in the great Mississippi basin, that it may be truly said no other one work has ever furnished so valuable criteria for the purposes of correct correlation of geological formations.

Of all fossil remains none are more admirably adapted for morphological study than those of the echinoderms. On account of their

abundance, their peculiarities in geographic and geologic distribution, and their structure, the stalked feather stars or stone-lilies are preëminent. With the skeletal parts composed of regular plates or ossicles, definitely grouped and frequently highly sculptured, all structural changes are readily deciphered.

The work on the crinoids is the outgrowth of studies begun more than twenty years ago, under the encouragement of Louis Agassiz, and prosecuted without intermission ever since. The entire work as contemplated will form two huge quarto volumes, of which the first, in two parts with an atlas of plates, has just been issued. Of the text there are nearly 800 pages; and the plates number 83, comprising 1500 illustrations artistically reproduced as photogravures. In the present installment—the Crinoidea Camerata—there are three main subdivisions; introductory, morphological and descriptive.

The introduction embraces an historical résumé of opinion and a full explanation of the terminology employed in description. Special attention should be called to the clear and concise definitions given of the various structural parts. The terms should be universally adopted as they form by far the best collection ever proposed. American writers especially will need no appeal to at once use them not only to secure uniformity in nomenclature but precision of description. Heretofore the names of the various plates or groups of ossicles have been used in a rather haphazard way. Not only have different designations been given to the same part, but the same title has been repeatedly applied to structures widely separated morphologically.

The morphological part contains the full discussion of the data upon which the entire classification of the crinoids rest, of the genetic relationships of the various groups, and of the structural characteristics.

The plates in general are separated into "Primary" and "Supplementary" pieces. The former occur in every crinoid and comprise the ossicles represented in the early larva, the basals, the infrabasals, the various plates of the rays or arms, the orals, and the joints of the stem. The supplementary pieces, which make their appearance in the more advanced stages, but which are altogether unrepresented in some groups, comprise the remaining plates. The primary ossicles belong either to the "abactinal" or to the "actinal" system. Those of the former including all the plates, connected with the chambered organ and axial cords; the others comprising those communicating with the mouth and the annular vessels surrounding it.

The stem is much more important than generally considered. It is composed of *nodal* and *internodal* joints, and continually increases in length in the growing crinoid by the production of new joints. The nodal plates in the Inadunata, Camerata, and a few of the Mesozoic and recent crinoids, are introduced directly beneath the proximal plate of the calyx, so that the uppermost joint for the time being, is the youngest joint of the stem. In the young Comatula, however, in which the top joint subsequently develops into a controversal, in the Mesozoic Millerocrinus and Apiocrinus, in the recent Rhizocrinus and Calamocrinus, and in all Ichthyocrinidae, forms in which the top joint in the early larva anchylose with the infrabasals, the new nodals are introduced below the top joint. The internodals are interposed between the nodal joints and increase continually in a downward direction during the life of the organisms *pari passu* with the formation of new nodal pieces. The stem matures from the root up, and remains permanently in a state of immaturity at its upper end. The maximum number of internodal joints varies among different forms. Sometimes there are many to the internode, as in the case of most species of Platycrinus, in Mespilocrinus and Rhizocrinus: sometimes only a very few; while Rhodocrinus, throughout its stem generally, has but one.

The cirri in Palæozoic crinoids are, as a rule, more formidable than in later forms, and in most of them they are confined to the lower part of the stem, often occurring only at the distal end. They are given off from the nodal joints, and are generally arranged singly, rarely in whorls as in recent forms.

It has been the general opinion that all Palæocrinoids are fixed forms, but this view is not now believed to be true. The facts appear to lead to the conclusion that at least many of the species in the later part of life were free for a portion of the time, as in the case of the recent Pentacrinidæ, in which the stem at some time at or near the maturity becomes separated from the root. The terminal end in most of the old crinoids tapers to a sharp point, but a root is rarely attached, while detached roots are found abundantly, but scarcely ever associated in the same stratum with the crown.

The real morphological relations of the Basals and Infrabasals is of particular interest. The latter term is adopted for the first plates in the base, and "basals" for the circlet next to radials. The basals of dicyclic crinoids always consist of five pieces; the infrabasals of five, rarely three. In monocyclic forms the base is divided into five, four,

three and two pieces, or all five plates may be anchylosed, so as to form a single piece. Among the Camerata five basals are restricted to the Lower Silurian forms, four basals to those from the Upper Silurian and Devonian, three to those from Upper Silurian to the Lower Carboniferous, and two in only some forms from the Carboniferous. The diminution in number takes place in geological succession, and is the result of fusion of two or more of the original five plates, as is clearly seen in genera without an anal plate between the radials. In forms, however, in which an anal plate is represented and the basal disk is consequently changed from a pentagonal to hexagonal shape the case is somewhat more complicated, for a bisection of the plates in the hexagonal base would produce six basals instead of five. The introduction of the anal among all the monocyclic groups is accompanied with an increase in the size of one of the basals, there being no special basi-anal plate. In the tripartite base, the smaller plate — always the left antero-lateral one — doubles its size. In the quadripartite base the increase is towards the right of the posterior plate; while in the bisected base in which the left postero-lateral basal, the antero-lateral, and the anterior one are fused, the two plates of the opposite side increase in size so as to correspond with the compound plate to the left. In dicyclic crinoids the introduction of the anal does not affect the arrangement of the infrabasals, and only slightly the form of the basals. In species with three infrabasals, one of the plates is always only one-half the size of the other two. This ossicle is, in the Ichthyocrinidæ and comatula larva directed toward the right posterior radial; but in the Inadunata its position is not constant. The basals of dicyclic crinoids are but little affected by the presence of the anal, only the upper angle of the posterior plate being slightly truncated.

When it was discovered several years ago, by Wachsmuth and Springer that among Palæocrinidæ there is a regular alternation of the successive parts below the radials it was also found that the orientation of the stem in the monocyclic groups is reversed in dicyclic forms. In the former the sharp outer angles of the stem are radial; in the latter interradial. The central canal and the cirri are interradial in the first mentioned forms, but radial in others. The law is, however, applicable to its full extent only in species with pentangular or pentapartite stems, but it is concluded from analogy that the circular stem, wherever it occurs is also practically interradial in dicyclic crinoids and radial in monocyclic ones. However, on applying the rule to mesozoic and later

crinoidæ it appears that in most of the so-called monocyclic forms, the orientation of the stem, central canal, and cirri agrees with the dicyclic type, the infrabasals being succeeded by a radial stem, as in those crinoids in which these plates are present but too small to be visible on account of being completely covered by the upper stem joint. Upon the strength of these observations, partly, these authors suggested that such forms either had small infrabasals hidden beneath the top stem joint, or those pieces had been represented in the larva. Other observations led to the same conclusion. In Extracrinus and in two species of Millericrinus, the former belonging to the Pentacrinidæ, the latter to the Apiocrinidæ, two of the principal families of the Pseudomonocyclia, small infrabasals actually exist, and it appears very improbable that those plates should be present in genera of the same family, and even among species of the same genus, and absent in others, especially when the space which in some of them is occupied by small infrabasals, is vacant in others, and interradially disposed instead of radially as it would be if the space represented the axial canal. On applying these observations to the Comatulæ it was found that the outer angles of the top stem joint in the Pentacrinoid larva of the Antedon, and the angles of the centrodorsal in the mature animal, did not come under the rules laid down for the Monocyclica, and this led to the conclusion that the Comatulæ also were built upon the dicyclic plan, and had infrabasals in early life. The predictions, which had been based exclusively upon palæontological evidence were afterwards verified by the observations of Bury, who actually found infrabasals in the ciliated larva of Antedon. They consist of three unequal pieces, which in the Pentacrinoid stage are fused together with the top joint, so as to form with the latter one large plate with the five angles radial in position. A similar fusion evidently takes place among palæozoic Ichthyocrinidæ, in which the infrabasals are also coalesced with the upper stem joint, as is shown by specimens in which the stem is detached from the crown. These individuals are in the same condition morphologically, as the two species of Millericrinus figured by de Loriol, in which the infrabasals coalesce with the stem contrary to the other species of that genus, and allied forms having the infrabasals more or less completely fused with the top joint. As this structure prevents the formation of new joints directly beneath the calyx, it is contended, from the analogy, that in all forms in which the infrabasals coalesce with the stem, the new stem plates are introduced at some

point beneath the top joint. The case is quite different in the Pentacrinidæ, where the youngest joint for the time being is the upper joint of the stem. Of the genera referred to this family, Extracrinus has small infrabasals persistent through life; while in Pentacrinus and Metacrinus no trace of these plates can be found in the adult; their stems are disposed interradially as in Extracrinus and other true dicyclic forms. That the plates are fused with the upper stem joint, is scarcely possible, as it would prevent the formation of new joints at the top; it is more probable as indicated by palæontological evidence that the infrabasals within the group, gradually diminished in size, and finally disappeared altogether. The structure of the Pentacrinidæ in this respect is very different from that of the Apiocrinidæ and Comatulæ, and it appears that crinoids in which the upper stem joint is the youngest, cannot be derived from types in which the upper joint is fused with the infrabasals. The latter therefore should be placed near the Ichythyocrinidæ and the Pentacrinidæ with, or close to the Inadunata.

These generalizations, so far as now known, meet with but two exceptions: the axial canal in the stem of Pentacrinus, contrary to that of Metacrinus and Extracrinus is interradially disposed; that of the monocyclic *Glyptocrinus fornshelli*, unlike that of the other species of the same genus, radially, so that the direction of the canals corresponds with the angles of the stem instead of alternating with them. This however does not invalidate the law, but simply points to the existence of the transition forms between the monocyclica and the dicyclica, as must have occurred at some time in the developmental history of the two groups if the one was evolved from the other.

The radials are less complicated in their morphological relations than the plates which they succeed. The term is now restricted to the first plate of each ray; and all succeeding pieces in a radial direction, whether free or incorporated into the calyx, are called brachials. In the earlier Inadunata and articulata but not in the Camerata so far as observed, the radials are frequently compound, being constructed of two segments, united by a horizontal suture, which in the organization of the crinoid corresponds to one plate. In most of the genera having compound radials the double ossicles, the two sections of which are called "infraradial" and "superradial," are confined to the right posterior ray, but they occur also in other rays but never in more than three, two of the radials at least being simple.

Recognizing the radials as practically a single plate in each ray, all plates above must be regarded as brachials to which pinnules may be attached. The terms costals, distichals and palmars are appropriately applied to the first, second and third orders of brachials respectively. When there are further divisions in the rays, the plates are designated as postpalmars, or as brachials of the fourth and fifth orders, and so on. A discrimination is also made between fixed and free brachials, the latter often being termed the arms. The arms are composed of one or two rows of plates. All biserial arms are uniserial in the young crinoid and gradually enter the biserial stage by an interlocking of the joints from opposite sides. In most of the families belonging to the Camerata the uniserial type is restricted to the Silurian, except in Hexacrinitæ. Among the Inadunata biserial arms occur only in a few genera found in the Kaskaskia, in the Coal Measures and in the Trias, but associated with the forms having the uniserial type. All Articulata, palæozoic as well as neozoic have uniserial brachial appendages.

The pinnules in a general way are repetitions of the arms on a small scale. When represented they spring alternately on opposite sides from every second joint and every joint bears a pinnule except in cases of a syzygy, in which the syzygyial plates must be counted in the alternation of the pinnules as one ossicle. Syzygies occur among Palæozoic crinoids either in successive series throughout the arm, as in the Heterocrinidæ and Belemnocrinidæ, or there is but one syzygy to each order of brachials, formed by the two proximal plates, as in Poteriocrinus, Dichocrinus, and in most species of Platycrinus. In Dichocrinus the various orders of brachials to the last axillary consist of two plates each, the first non-pinnulate, the upper bearing an arm instead of a pinnule. A similar arrangement occurs above the costals in most species of Platycrinus and it is quite evident that the plates in question, as in Dichocrinus for example, do form a syzygy. This, however, is not the case is such forms as *Platycrinus huntsvillæ* and a few other species. Here the first pinnule is given off from the proximal distichal, and the second on the same side from the first palmar. It shows clearly that the arm partakes of the alternation of the pinnules, and suggests that the armlets are enlarged pinnules. This is shown more conclusively by the structure of *Glyptocrinus dyeri*. While in most species of Glyptocrinus the second bifurcation takes place from the second distichial, that plate in *G. dyeri* gives off in place of an arm a large pinnule, more than twice as large as an ordinary one, which bending outward

forms an angle as in the case of a true bifurcation. The second pinnule, which is somewhat smaller starts off from the fourth distichial on the opposite side as in the other species of the genus. All succeeding pinnules are small, and are given off alternately from successive joints.

The oral plates have been the subject of much controversy, but their identification in the different groups is now pretty well established. According to Wachsmuth and Springer the orals are not always represented in the adult. When present they surround the mouth or cover it. They may occupy the whole face of the ventral disk or only its median portion. In the former case they rest upon the edges of the radials; in the latter against the perisome. In crinoids with a regular pentamerous symmetry they consist of five pieces interradially disposed, and form the center of the disk. When the symmetry is irregular they are pushed more or less to the anterior side. The former condition prevails among recent crinoids; the latter is the general rule among palæozoic forms. When asymmetrical, the posterior oral by the encroachment of the anal plates, is pushed between the four others, so as to attain a more or less central position. The plate is generally larger than the other four. The orals in all groups in which they are represented consist of five pieces. There is no such thing as an orocentral plate, as some writers have supposed. In some instances the orals seem to be wholly or partly resorbed; the former condition probbly is the case among the Camerata, the latter in certain species of the Fistulata. In regard to the Ambulacra it is now generally admitted that the aperture in the tegmen of palæozoic crinoids is not the oral opening but the anus, and the mouth is subtegminal forming the center of radiation, which, however, is not necessarily the geometrical center. The ambulacra follow the grooves along the ventral side of the arms, and extend from the tips of the pinnules to the mouth. Their inner ends are either exposed upon the disk, or covered wholly or in part by plates of the tegmen. The upper face of the ambulacra is occupied by the food grooves, which are roofed over by the covering plates and frequently are boarded by side pieces. In recent crinoids the covering plates are movable from the tips of the pinnules to the entrance to the mouth; but in most palæozoic ones those of the disk are rigid, so far as known, often heavier, and larger than the intervening plates. The disk portions of the ambulacra in the Camerata, if tegminal form a component part of the tegmen, their plates being suturally connected with one another and with surrounding plates; those

in the Fistulata rest upon the edges of large interradial pieces. When the ambulacra are subtegminal they enter the calyx by the arm openings, and follow the inner floor to the proximity of the mouth.

The "supplementary plates" comprise all calcareous particles between the basals and orals, and between the rays and their subdivisions. They are interradial, interaxillary or anal. The interradial plates which are separated into interbrachials and interambulacrals, comprise all pieces between the basals and orals interradially disposed, the former being confined to the dorsal cup; the interambulacrals occupy only the spaces between the ambulacra. The interaxillaries, which consist of the interdistichals and interpalmers are located within the axils of the second and third orders of brachials respectively. The anal plates are restricted to the posterior interradial area, and support the anal tube. Another system of supplementary plates occurs in the acrocrinidæ, between the basals and radials. In groups in which the arms are not entirely free from above the radials, the lower arm plates are incorporated into the calyx by means of interbrachials; and the orals are carried inward toward the actinal center by interambulacrals. The supplementary plates increase in number in the growing crinoid. They are undeveloped in the early larva and in the Laviformiæ. In the Fistulata they are represented only in the tegmen, except in the case of the anal piece. The plates vary exceedingly in form and character, being in some groups well developed and rigid, in others irregular and imperfectly formed or mere lime particles within soft tissues. The great variation in the structure of the plates formerly led to the belief that the rigid and regularly arranged pieces, so characteristic of the Camerata, did not belong to the same system as the irregular small pieces which unite the rays in recent form. A distinction was also made between the ossicles of the tegmen. The heavy, rigid components of the palæozoic forms called "vault" pieces the irregular smaller ones "disk" plates; and it was supposed that many of the older crinoids had a vault with a disk underneath. That they had two integuments was believed to be indicated by the condition of the ambulacra, which in recent crinoids are exposed, while in palæozoic types they are either completely subtegminal, or the food grooves are rigidly closed by immovable covering pieces. This supposition, however, has proved to be an illusion and to be based upon inaccurate observation. Even in species of Batocrinus and Dorycrinus, in which deception seemed to be almost impossible, it is ascertained from excellent material, that the

tegmen consists of but one set of ossicles and that the plates are suturally connected and solid on the outside, but perforated and vesicular within. The condition of the ambulacra in camerate crinoids, whether tegminal or subtegminal, does not represent an essential structural feature, but is a natural consequence of differences in the form and construction of the tegmen in the respective groups and as such cannot be of much value from a morphological or classificatory point of view. Subtegminal ambulacra, as a rule, are most prevalent in species with high dome and bulging arm basis; while forms with a flat or depressed ventral surface generally have tegminal ambulacra. The two styles occur side by side among species of the same genus, and there exist all possible transition forms between the two extremes, *i. e.*, specimens in which the ambulacra are subtegminal at the median portions of the disk, and tegminal near the periphery. By comparing the younger individuals with the older, it appears that the covering of the ambulacra is produced in the growing animal by the gradual extension of the interambulacral areas along the lines of the ambulacra, either completely covering them, or leaving the portions next to the arm basis exposed. The ambulacra of the Camerata, therefore, are covered not by an element unrepresented in other groups, but by small superimposed plates passing out from the disk proper. These plates were quite small in the Silurian species, but change essentially until in the Carboniferous they frequently attain the large size and rigidness of the other plates in the tegmen. As to the closure of the mouth, it is now believed that it was subsequent to the introduction of the anal plate, by means of which the posterior oral was pushed in between the four others so as to close the opening.

The interbrachials and interambulacrals, in most of the Camerata, pass insensibly into one another, there being no line of demarkation by which they may be separated, except that produced by the arms, and it is difficult to understand how these plates can be distinct structures as is generally supposed. That their morphological relations are very close is conclusively shown by the fact that the very same plates which in the Actinocrinidæ and Batocrinidæ are strictly interbrachial, are in the Platycrinidæ and Hexacrindidæ partly interbrachial and partly interambulacral, and in the Cyathocrinidæ exclusively interambulacral. That the plates of the two hemispheres occasionally are interrupted, notably in Batocrinus, Catocrinus and Strocrinus, is readily explained by the large increase that here takes place in the number of arms, which prevents the development of interbrachials around the arm bases.

Essentially different is the ventral structure of the Fistulata, which have no interradial plates in the dorsal cup, the anal plate excepted, but which have these pieces extensively developed in the tegmen. Four of the interambulacral spaces are raised but little above the level of the arm bases, while the posterior area is extended abruptly upward, and is formed into a tube or sac of variable shape and size, rising beyond the tips of the arms. This sac, which may be regarded as a greatly extended anal area, probably lodged a large portion of the visceral mass. The sac is generally composed of longitudinal rows of hexagonal plates, and is often perforated by pores. The structure at the four other sides of the disk is rarely observed except among the Cyathocrinidæ in which it is probably more substantial than in other groups. In Cyathocrinus there are six plates, interradially disposed, resting against the inflected upper edges of the radials, the lateral margins being covered by the ambulacra. Four of them are large and of equal size, the two others, lying at the posterior side, are quite narrow and enclose a madreporite. The margins of the larger plates are roofed over in perfect specimens by numerous small irregular pieces, while the perforated plate is exposed to view.

Most of the Ichthyocrinidæ have interbrachial plates, which in some forms are large and massive, in others small; some are arranged regularly, others irregularly, but all are movable. The plates of the tegmen are very minute and irregularly arranged, the ambulacra are tegminal, and the mouth and food grooves are open. Thus there is among palæozoic crinoids a tegmen having all the characteristics of the disk in recent species, demonstrating conclusively that the disk as a vental structure is not confined to the neocrinoids as generally supposed. Moreover, a careful study of the various tegmens in the different groups shows that there are represented among them all intermediate stages from the simplest disk to the most rigid and complicated "vault" of the Actinocrinidæ, and that the so-called vault is a highly modified form of the disk.

The anal plates bear a most important part in the phylogeny of palæozoic crinoids, and they are among the best criteria for purposes of classification. When present they occupy, in the Camerata, the median line of the posterior area so as to divide the interbrachial plates into two equal sets, and being in rows containing an odd number they have the effect, as it were, of breaking up the middle plate into two, as in cases where no anal plate is inserted between the sections.

The anal plates vary considerably in their position and distribution, and, in some groups are absent altogether. As a rule they are largely represented in species with a stout tube or a lateral opening, and are wanting or are poorly developed when the anus is central.

Among the Fistulata the term "anal plates" has been applied to two ossicles of different origin, the one radial, the other interradial. The latter is the homologue of the first anal of the Camerata, and rests upon the truncated posterior basal. The other which is not a supplementary plate but the lower section of the compound right posterior radial, performs anal functions only in certain genera. When both plates support the ventral sac as in most of the Poteriocrinidæ, the second, which is actually the first or lowest in point of position, is placed obliquely to the right of the other, without disturbing the orientation or the alternate arrangement with the basals. Both plates undergo many modifications, and the various phases as they occur in different geological stages, may be regarded as excellent criteria for generic separation. The earlier Camerata have neither a radi-anal nor a regular anal plate both of which make their appearance with the increasing size of the ventral sac. As this grows larger, the two posterior radials which previously were in contact laterally, part, and the anal piece is introduced to support the sac. Afterwards when the ventral sac attains still greater proportions, the supraradial is shifted to the right in a position almost directly above the right postero-lateral basal, so as to give to the infraradial which retains its place, a rather oblique direction. In the Poteriocrinidæ, in which the lower faces of the costals fill up the whole width of the radials, leaving no room for attachment, the lower plates of the sac enter the calyx. At the close of the Carboniferous, the sac becomes reduced again to its former insignificance, the anal plates generally disappear, and the two posterior radials meet again laterally. This interpretation of the origin of the anal piece (or plate *x* as it is frequently called) differs essentially from that given by the English writers on the crinoids and particularly by Mr. Bather, who regards the plate as primitively derived from a brachial, which in time passed down from above into the dorsal cup. This author also claims that in the older forms with a compound right-posterior radial, such as in Iocrinus and Heterocrinus, the plate in question is supported by the supraradial and does not touch the infrabasal; but that, further, in Hybocrinus and Dendrocrinus, it passes down from above the radial and finally rests with its lower half between the two posterior radials,

then being supported partly by the basals and partly by the infraradial; and that in Carabocrinus, Botryocrinus, and allied forms the said ossicle has sunk to a line with the radials. Mr. Bather evidently has confounded here plates which are morphologically quite distinct. In the above genera the plate under consideration is represented only by Dendrocrinus, Carabocrinus, and Botrycrinus. The piece to which reference is made in Iocrinus, Heterocrinus and Hybocrinus is a plate of the ventral sac, as is conclusively proven by Dendrocrinus, otherwise it must be admitted that the plate would be represented twice in the same specimen, by the true anal plate which rests upon the basals, and by the tube plate (of Iocrinus) which is supported by the supraradial. The anal area of Dendrocrinus is like that of Poteriocrinus, only that the superradial of the former does not move away from the inferradial, as it does in the latter. This is not necessary in a form like Dendrocrinus in which the arm-facets occupy a comparatively small part of the radials and leave ample space for the support of the tube. In the Poteriocrinidæ, however, in which the upper surface of the radials is taken up completely by the costals, the foundation of the tube is not adequate to the width and the deficiency is manifestly made up by a shifting of the superradial and the introduction of another plate for the support of the tube.

In the anal interradius, as it appears in the various families of the Camerata, a close agreement is found between the anal plate (x) and the tube plates of the Fistulata on one side, and the anal plate and interradials on the other. Admitting this, a more satisfactory explanation of the anal plates of the Fistulata is reached than that given by Mr. Bather whose views do not cover the Camerata; besides being based upon premises which appear to be entirely hypothetical. If it were true that Bather's plate x of Iocrinus passed down in later forms from above the superradial to the basals, it would certainly require a partial revolution of the whole tube; but this is clearly disproved by the structure itself, which throughout its full length is composed of hexangular pieces, regularly arranged in longitudinal rows. Bather also regards the anals of the Camerata as morphologically distinct from those of the Fistulata, while there actually seems to be good grounds for believing that the plate x of the latter is homologous with the first anal in the Camerata, and also with the anal which for a time occurs in the larva of the Comatulæ; but that the Camerata have no radi-anal for the simple reason that they have no compound radials. The anals

of the Icthyocrinidæ are arranged in a similar way to those in the Fistulata. Some of them have only the plate *x* represented, others only the radi-anal, still others both, and some of them have no anal plate at all. The Larviformia have neither the one nor the other, although they have frequently compound radials. The anal tube where it occurs, is inserted intermediate between the radials and orals.

The systematic arrangement of the crinoids as proposed by Wachsmuth and Springer is one that will require but few material changes for a century to come. Based entirely upon morphological principles, with a completeness and wealth of ontogenetic and phylogenetic data that is rarely obtainable among fossil organisms, the essential elements of classification are more firmly grounded than perhaps in any other group. No attempt in recent years towards a natural and rational orderly arrangement of a large and complex assemblage of organic remains has been so signally successful. Nor has the evolution of the groups in time and space been neglected. For classificatory purposes special emphasis should be placed upon a number of features. Of very great importance is the growth of the stem, whether the young joints are formed beneath the proximal ring of the calyx or beneath the top stem joint. Particular stress is also to be placed on the alternate arrangement of the stem with the lower ring of plates in the calyx, by which it is determined that by far the large majority of the neozoic crinoids are dicyclic and not monocyclic. Of exceptional significance are certain features in the Ichthyocrinidæ which clearly indicate affinities with the Apiocrinidæ, Bourgueticrinidæ, Eugeniacrinidæ, and Comatulæ all five groups of which are placed together among the Articulata. All have a disk composed of small, irregular, and movable pieces, with open mouth and open food grooves, all are dicyclic, but the infrabasals coalesce with the top stem joint, so as to prevent the introduction of new joints directly beneath the calyx. From the Articulata are excluded the Encrinidæ and Pentacrinidæ which are generally arranged with them. The infrabasals of the former of the two families are very small, or are resorbed in the growing animal, but they do not coalesce with the top joint which is therefore for the time being the youngest joint of the stem. The Pentacrinidæ have, through the Encrinidæ, close affinities with the Poterocrinidæ, and probably are their descendants, but if they really belong to the Inadunata as is now believed they represent somewhat abberant types, for the lower brachials take part in the calyx.

Not less important than the morphological contributions to a knowledge of the stemmed echinoderms are the advancements made in their classification, and it is safe to say that the systematic arrangement of the group is now practically settled for a century to come.

The three groups of stalked echinoderms, the cystids, blastoids and crinoids are regarded as orders of equal rank. The forms of the first are earliest in time and lowest in taxonomic position, and may be considered the ancestral types of the other two. The crinoid type itself is a very old one, dating from the Cambrian, in which it was already in a high stage of development. During the Ordovician the cystidian features almost wholly disappeared. The crinoidal group is remarkable for the persistency it has shown in preserving its pentamerous symmetry, and although the introduction of the anal plate was a disturbing element so great as to well-nigh produce a lasting bilateral arrangement, the former type was finally permanently retained.

The two primary groups of crinoids which were formerly almost universally accepted are abandoned. These are the Neocrinoidea and Palæocrinoidea. In their stead are recognized three principal subdivisions: Inadunata, Camerata and Articulata. It is particularly noteworthy that this ternate grouping of the crinoids is essentially the same as Wacksmuth originally proposed more than twenty years ago and that after being compelled by students of the recent forms to abandon it and to substitute others, a final careful survey, in the light of recent discoveries, of all crinoids both living and fossil, has clearly shown that the main subdivisions first suggested are essentially valid and are applicable to all known forms. The criteria for separating the crinoids into orders are briefly:

1. Condition of arms, whether free above the radials, or partly incorporated in the calyx.

2. Mode of union between plates of the calyx, whether movable or rigid.

3. Growth of the stem, whether new plates are formed beneath the proximal ring of the calyx or beneath the top stem joint.

The simplest forms of the Crinoidea Inadunata have the dorsal cup composed invariably of only two circlets of plates or three where infrabasals are present; there are no supplementary ossicles except an anal piece which is however not always present; the arms are free from the radials up. In the construction of the ventral disk two different plans are recognizable and upon these are established two subgroups—

the Larviformia and Fistulata. The former has the disk in its simplest possible form, being made up of five large orals arranged in a pyramid; the second has the ventral side extended into a sac or closed tube, often reaching beyond the ends of the arms.

The Camerata are distinguished by the large number of supplementary pieces which bring the proximal arm plates into the calyx, thus enlarging the visceral cavity. All plates are heavy and immovable and the mouth and food grooves are tightly closed.

The Articulata have to some extent the incorporation of the lower arm plates with the calyx, but the plates are movable instead of rigid. The mouth and food grooves are open. The infrabasals are fused with the top stem joint which is not the youngest plate of the stalk. According to whether or not the pinnules are present two suborders are recognized: the Pinnata and Impinnata.

For the family distinctions the supplementary plates constitute excellent features for classification, and while of small importance physiologically, they form a good example of a truth which is met with everywhere in biology that characters of physiological value are not always of equally great utility for purposes of classification. Of prime import in this regard are the anal pieces.

Of the three groups of crinoids having ordinal rank, that constituting the Camerata is by far the most important. An analysis of the families is briefly as follows:

I. Lower Brachials and Interbrachials Forming an Important Part of the Dorsal Cup.

A. Interradials poorly defined.

Lower plates of rays more or less completely separated from those of other rays and from primary interradials by irregular supplementary pieces; anal interradius divided by a row of conspicuous plates; (dicyclic or monocyclic) ..... Reteocrinidæ

B. Interradials well defined.

1. Dicyclic.

a. Radials in contact, except at the posterior side ..... Thysanocrinidæ

b. Radials separated all around ..... Rhodocrinidæ

2. Monocyclic.

a. Radials in contact all around. Symmetry of the dorsal cup if not strictly pentamerous, disturbed by the introduction of anals between the brachials only ..... Melocrinidæ

Arms borne in compartments formed by partitions attached to tegmen; dorsal cup perfectly pentamerous; plates of calyx limited to a definite number ..... Calyptocrinidæ

b. Radials separated at the posterior side by an anal plate.
First anal plate heptagonal, followed by a second between interbrachials. ..... BATOCRINIDÆ
First anal plate hexagonal, followed by two interbrachials without a second anal; arms branching from two main trunks by alternate bifurcation ..... ACTINOCRINIDÆ

II. BRACHIALS AND INTERBRACHIALS ONLY SLIGHTLY REPRESENTED IN THE DORSAL CUP.

1. Dicyclic.
Radials in contact except at the posterior side ..... CROTAOCRINIDÆ
2. Monocyclic.
a. Radials in contact all around; base pentagonal ..... PLATYCRINIDÆ
b. Radials separated on posterior side by an anal plate; base hexagonal. Basals directly followed by the radials ..... HEXACRINIDÆ
Basals separated from radials by accessory pieces ..... ACROCRINIDÆ

While the morphological and classificatory chapters of the monograph on North American crinoids appeal more directly to palæontologists interested in the biological side of the subject, the descriptive part will be of greatest practical value to the stratigraphical geologist. This portion of the work is a complete revision of all Camerata known from this country up to September 1894. Every species is fully and clearly described compared with closely related forms, beautifully illustrated and referred to its proper geological horizon; the full literature of each and the localities where it occurs are also given. All the species have been redescribed from the most perfect material that could be found in all museums and private collections. The liberality shown Wachsmuth and Springer by those persons who possessed suitable specimens in placing them at free disposal is to be commended in the highest terms. It was the means of making accessible nearly all the type specimens known, and in fact, most of the crinoid material in the country. In addition there were the authors' own magnificent collections which contain more than nine-tenths of the known American species and over two-thirds of the European, of which many are represented by scores and even hundreds of individuals. These large collections gave new ideas regarding the limits of the different species and enabled a discrimination to be made between species and varieties, and between the young specimens and the adults, which led to the elimination of a large number previously recognized. The establishment of species on rational morphological grounds and not on trivial superficial or accidental characters which are relatively unimportant as classificatory criteria is a point of excellence which cannot be too highly praised, and one which should

be the central consideration in the revision of the nomenclature of all groups of fossils as well as living organisms. That there has long existed a burdensome and extensive synonomy among crinoidal as well as all other classes of animals no one who has given the subject attention will for a moment question. The most casual consideration has rendered apparent the urgent necessity of a careful and complete revision of nearly all groups. The wide geographical distribution of many species and the concomitant changes of environment may readily be referred to as among the chief causes of local variation in species now living. Among fossil forms, however, there is in addition a greater factor of geological range which must be carefully considered. Notwithstanding the careful and conscientious labors of a large number of writers, little attention has been given in the description of species to these highly important factors which for the most part have been entirely overlooked. But the contributions to synonymy have not originated wholly in the manner mentioned. A still greater number of invalid names have come from a practice which cannot be condemned in terms too severe. It is the tendency to describe species, and genera also, from imperfectly preserved material, often from a single aberrant specimen, without making adequate comparisons with allied forms. This deplorable state of things, which in the natural course of events should be continually getting better with the advance of knowledge, appears of late years to have become so virulent that it is a serious question whether such work should not properly be ignored altogether. It will ever remain one of the crowning glories of Wachsmuth and Springer's efforts that they have shown no sympathy whatever with such work; and that with calm, untrammeled and truly scientific judgment they have relegated to oblivion such a large number of worse than useless specific names which have so long stood as a menace to progress in this field of palæontologic research. A full list of synonyms so far as they apply to the Camerata is given.

The preparation of the monograph occupied over seven years of continuous work, but this gives but a faint idea of the vast amount of labor involved. This work will be indispensable to all future writers on crinoids, as well as to the collector in the identification of his material. It embraces the whole literature on the subject and thus dispenses with dozens of papers which are not accessible to the student. Besides it has the great advantage that the same terms are used throughout the whole work, and that these terms are clearly and accurately

defined. The identification of the forms is facilitated by analytic tables for families and genera; and the species are arranged under the various genera in such a way that those most closely related are placed near one another. There is a general index, and an index of the authors quoted. CHARLES R. KEYES.

En resa till norra ishafvet sommaren 1892, företagen med understöd af vegastipendiet. [A Journey to the Arctic Ocean during the Summer 1892, made with the aid of the Vega Stipend.] By AXEL HAMBERG. Reprint from Ymer, 1894.

The author accompanied a Norwegian sealer visiting Beeren Island and the Spitzbergen Islands. In King's Bay a stay of several days was made, and the author studied some ice fields, which he named Lovèns névés. On the surface of the ice at this place but few small lateral moraines were to be seen, but in a fracture of the ice an inner moraine was observed. This consisted of about ten strata of assorted gravel and sand alternating with layers of ice. It was evidently a medial moraine in the lee of a projecting low mountain top, seen several miles inland. It is stated that similar features are common in the ice fields of these arctic islands. The author suggests that, if the ice were melted away, such moraines would give rise to structures much resembling åsar, both as to the contained material and as to the form and direction of the resulting topography. At one place some of these deposits were seen extending a distance at right angles away from the ice margin and resembling somewhat the Scottish kames. The névés were composed of bedded ice, in some places extending out in the sea. In several instances it had been melted away under the water and marginal blocks had evidently been detached by their own weight, leaving the edge of the ice standing in vertical smooth walls as if "cut off with a knife."

A number of photographs were taken with a camera fitted for photogrammetric measurements and a map constructed from these photographs accompanies the paper. The névés represented on this map are seen to occupy valleys among several small groups of hills and extending to within less than a mile from the shore. The front edge of the ice sometimes forms an evenly rounded curve and sometimes a vertical cliff from 60 to 100 feet high. It is suggested that this difference in the behavior of the terminal edge (when resting on the land) may be due to a difference in the morainic material of the